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Coping mechanisms adopted by the livestock dependents of drought prone districts of Bihar, India

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ABSTRACT

Coping mechanisms adopted by the farming community has recently become a subject of increasing importance in climate change research with an objective to reduce the vulnerability of climate sensitive people. The present study was designed to identify and assess the coping mechanisms adopted by the livestock dependents to mitigate the impact of drought on their livestock rearing and livelihood security. A total 240 livestock dependents from three drought prone districts of Bihar were interviewed and an exclusively Drought adaptation Index was developed for this study. The study revealed that 49 adaptation strategies were adopted by the livestock dependents which were further distributed into seven broad categories. Most significant coping mechanisms were feeding of extra crop residues, providing frequent extra clean and fresh feed and water, storage of wheat/rice straw, change in cropping pattern, feeding and milking during cool hours, kept animal in shadow, extra bathing of cattle, feeding of extra concentrate, selling of animals and reducing herd size. The study also established that adoption of coping mechanism was increased significantly with the increase in degree of drought proneness and herd size was the most significant contributor to the higher level of adoption of coping mechanisms.

Key words: Bihar, Coping mechanisms, Drought, Livestock dependents

Drought may be defined as an extended period that is a season, a year or more of deficient rainfall relative to the statistical multi-year average for a region. Simply, drought is a period of drier than normal conditions that lead to water-related problems. If dry weather persists and water supply related problems increase, then, the dry period can be called a drought (Nagarajan 2010). India Metrological Department defines that when an area receives rainfall less than 75 percent of its normal rainfall, it is considered as drought; if rainfall deficit is between 26–50%, it is moderate drought; and if rainfall deficit exceed 50%, it will be under severely drought (IMD 2002). Again, the areas, where drought has occurred in at least 20% of the years examined are classified as drought prone area (IMD 2002). India has a long drought history (FAO 2013, Mishra and Singh 2010, and World Bank 2003). Bihar is a predominant disaster prone state of India. Large areas in Bihar have suffered moderate to severe droughts in four out of five years from 2009 to 2013. The period from 2009 to 2013 has been the driest continuous five-year period in more than a hundred years for which we have weather records in Bihar. In 2009, along with many other states of India, Bihar faced severe drought in 26 out of 38 districts. Bihar also faced its fourth drought in 2013 within a span of last 5 years (2009–2013) and it had been declared 33 out of 38 districts as drought affected. Due to huge rainfall deficit during the sowing season in 2013, late transplantation of paddy, acute summer heat, wilting of crops and virtual midseason withdrawal of monsoon (since September witnessed very little or no rain), the total estimated crop damage in the drought affected 33 districts during *kharif* 2013 was 1,258,974 ha for paddy transplanted and 222,579.5 ha for maize totaling to 1,481,554 ha. The estimated loss of production of rice due to the deficient monsoon in these 33 drought affected districts was 3,618,230 MT. The estimated loss of production of maize was 508,083 MT in 2013 (Anonymous 2014). In India, productivity of the livestock is also depended on rainfed agriculture as crop residues are used as livestock feed. Hence, along with crops, livestock productivity was severely affected due to the feed and fodder scarcity (Syomiti *et al*. 2015, Udmale *et al*. 2014 and Rathore 2005). Ultimately, this creates a disaster and affected livelihood of the people of Bihar. To get relief from these disasters, livestock dependents adopted several mechanisms which are found, sometimes, very worthy one. Kattumuri *et al.* (2015) concluded that farmers adopted several practices to cope with current climate risks which include shifting

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cropping pattern (to more resilient but low economically valued crops and varieties), mixed cropping, agroforestry (as a long-term strategy), and diversified livestock holdings. Therefore, farmers led coping mechanisms are required to be documented to cope up with adverse impact of drought. Keeping in view all these, a comprehensive study was conceptualized on the adoption of the coping mechanisms by the livestock dependents of the drought prone districts of Bihar for skilful implementation that helps to reduce vulnerability to prosper their socio-economic status and overall quality of life.

MATERIALS AND METHODS

The study was conducted in Bihar, which had been selected purposively keeping in view the recent droughts. To trace the degree of drought proneness, daily rainfall data for 30 years (1984–2013) of different coordinates of Bihar was collected from India Meteorological Department (IMD), and based on this data the number of years of drought faced by each district of Bihar was calculated. Further, based on number of drought years, all 38 districts of Bihar were categorized into three strata i.e. non-drought prone, moderately drought prone and severely drought prone. It was found that there were 17 districts in non-drought prone category, 13 were in moderately drought prone category and remaining 8 were in severely drought prone category. From each category, one district was selected randomly. Thus, Gaya district selected from non-drought prone category, Samastipur district from moderately drought prone category and Bhagalpur district from severely drought prone category. From each district, two blocks were selected randomly and from each selected block two villages were selected randomly. From each village number of livestock dependents (who have at least 50% of their income from livestock sector) were quantified and from each quantified number of livestock dependents, twenty (20) respondents were selected randomly. Thus, total sample size for the present study was 240.

Operationalizaton and measurement of coping mechanisms: Coping mechanism was referred to adjustment in ecological, social or economic systems in response to actual or expected impacts due to drought. Coping mechanism was operationalized as the measures adopted and/or followed by the livestock dependents to cope up with the adverse impact of drought on livestock rearing and/or their livelihood for sustainable livestock productivity and/or sustainable livelihood security. A list of coping mechanism was prepared with the help of review of literature, pilot study and experts consultation. Livestock dependents were requested to put their response on a three point continuum viz. continued the adoption, discontinued the adoption and never followed/adopted with the score of 2, 1, and 0 on the prelisted coping mechanisms. All the identified coping mechanisms were used for final index development for all the studied districts. Therefore, in order to quantify the coping mechanism and the differential level of adoption, a "Drought Adaptation Index" was developed underlying the principle of Maiti *et al.* (2014a) by using the following formula:

$$\text{Drought adaptation index (DAI)} = \frac{\text{Obtained score}}{\text{Maximum obtainable score}}$$

Coping mechanisms with higher index value indicated more cope up capacity comparatively to the coping mechanisms with lower index value. Ranking of these coping mechanisms were done according to their higher index value. Further, stepwise multiple regression analysis was applied to find out the reasons of higher level of adoption of coping mechanisms.

RESULTS AND DISCUSSION

Total 49 coping mechanisms were adopted by the livestock dependents of drought prone districts of Bihar, India. All these 49 coping mechanisms were distributed into seven broad categories and which are discussed with their rationale as follows.

Use of feeding materials during drought: Livestock dependents of each studied district perceived that lack of feed and fodder abundantly during the period of drought and hence decrease in feed intake of their livestock results into decrease in productivity of livestock. Therefore, they used to provide extra crop residues, extra concentrates to the livestock to maintaining productivity. Maiti *et al.* (2014a) reported that provision of extra concentrate to livestock feeding, providing minerals supplementation and feed additives, change in feeding schedule, change in grazing time. It was also found that livestock dependents used to feed immature paddy crop which have no chance to grow up due to water scarcity. They also provided maize stover as feed and fodder to the livestock because of availability of maize in the study area. They used to allow grazing their animal alongside road when grassland of these areas dried due to drought.

Livestock dependents had a believe that animal also having same mechanism of sweating under hot and humid environment as in human. Due to excessive sweating reduces body minerals level like sodium and potassium. Therefore, they practiced to provide common salt and mineral mixture available in nearby shop/market to maintain the mineral quantity in animal's body. According to Mallone *et al.* (1985), lactating milch animal especially cows fed complete mixed diets of supplementation of potassium (K) and Scheider *et al*. (1984) suggested potassium (K) and sodium (Na), which leading to enhance milk yield from 3 to 11%. Livestock dependents also provide some feed additives like vitamins and micronutrients like zinc etc. to reduce the negative impact of heat stress, improve milk quality and to improve health condition of their livestock. Table 1 clearly indicates that there are seven coping mechanisms adopted under the main heading of coping mechanism, "use of feeding material used during drought". These 7 different coping mechanisms had been ranked on the basis of index value for each district separately. It was

found that the coping mechanism 'feeding of extra crop residues' was having highest preference in each district with an index score of 1. It is indicated that all the livestock dependents of each district adopted this coping mechanism and continued this practices by remembering its importance. Second important coping mechanism adopted by livestock dependents in severely drought prone district was 'providing minerals supplementation and feed additives instead of green fodder', while second important coping mechanism adopted by the livestock dependents of moderately and non-drought prone district was 'feeding of extra concentrate to the livestock'.

Feeding practices followed during drought: Livestock dependents provided limited/controlled feed/fodder to their livestock due to scarcity of resources of feed and fodder during drought conditions. Sometimes they fed to animals only ensure to its survival or to maintain production at some extent to fulfill their family consumption. Upadhyay *et al*. (2009) reported that animals should be fed during morning hour because heat in the middle of the day would on peak due to higher environmental temperature. Therefore, majority of livestock dependents of severely drought prone district (Bhagalpur) followed this practice. Due to non availability of owned fodder resources, livestock dependents purchased feed and fodder from outside (where fodder available abundantly) to maintain the desired productivity to their animal. They also used to provide their animal frequent clean and freshwater and feed to alleviate heat stress. Upadhyay *et al.* (2009), and Sirohi and Sirohi (2010) reported that the frequency of feeding should be increased and lower quantity of ration should be given during the day in order to improve the dry matter intake during summer and to reduce heat stress. They also reported that fresh feeding improves dry matter intake and fresh feed at some interval encourages the taste to animal to eat large quantity of ration.

Table 2 clearly depicts that the coping mechanism 'providing frequent extra clean and fresh feed/water to the livestock to alleviate heat stress' was having higher level of adoption as a coping mechanism by the all most all the livestock dependents of each district. Adaptation practices like 'limited/controlled feed/fodder provide to the livestock' and 'feeding to animals only ensure to its survival or to maintain production at some extent and growth' were having second position and equal importance among the livestock dependents of severely drought prone district followed by practice like 'to maintain desired production by purchasing feed and fodder from outside'.

Strategies for meeting feed shortage in advance: Droughts have been reported to cause failure and damage

Table 1. Index score and ranking of use of feeding materials during drought as coping mechanism followed by livestock dependents of study area

Feeding materials	Non-drought prone (Gaya; n=80)	Moderately drought prone (Samastipur; n=80)	Severely drought prone (Bhagalpur; n=80)
Feeding extra concentrate to the livestock	0.93 (ii)	0.99 (ii)	0.96 (iv)
Feeding of extra crop residues	1.00 (i)	1.00 (i)	1.00 (i)
Feeding immature paddy crop which have no chance to grown up due to scarcity of water	0.59 (v)	0.93 (iii)	0.98 (iii)
Feeding maize as fodder to the animals	0.63 (iv)	0.81 (iv)	0.79 (v)
Feeding of tree leaves	0.24 (vi)	0.27 (vi)	0.59 (vii)
Grazing the animals along road/canals/field	0.78 (iii)	0.68 (v)	0.75 (vi)
Providing minerals supplementation and feed additives instead of green fodder	0.93 (ii)	1.00 (i)	0.99 (ii)

Values in parenthesis indicates the order of merit of preferences by the livestock dependents column wise

Table 2. Index score and ranking of feeding practices as coping mechanisms followed by livestock dependents of study area

Feeding practice	Non-drought prone (Gaya; n=80)	Moderately drought prone (Samastipur; n=80)	Severely drought prone (Bhagalpur; n=80)
Limited/controlled feed/fodder provide to the livestock	0.44 (iii)	0.39 (iv)	0.91 (ii)
Feeding of animals only to ensure its survival or to maintain production at some extent and growth	0.43 (iv)	0.43 (iii)	0.91 (ii)
To maintain desired production by purchasing feed and fodder from outside	0.66 (ii)	0.94 (ii)	0.87 (iii)
Providing frequent extra clean and fresh feed/water to the livestock to alleviate heat stress	0.99 (i)	1.00 (i)	0.99 (i)

Values in parenthesis indicates the order of merit of preferences by the livestock dependents column wise

to crop and leading to chronic food shortages for livestock (Liwenga *et al.* 2007, Kangalawe and Liwenga 2005). Therefore, livestock dependents used to store wheat/paddy straw at the time when abundantly available so that it could be provide at the time of lean period. Storage by making hay was a common practice followed by livestock dependents. Maiti *et al.* (2014a) reported that use of more amounts of crop residue and hay at the heat stress period was an important coping mechanism. Livestock dependents used to provide mixed ration of husk (*bhusa*), maize (*makka*), wheat (*gehoon*), common salt (*namak*) and minerals at the time of shortage of fodder availability in order to enhance the productivity of animals.

Drought mainly affects the crop and livestock production, therefore, farmers preferred not to sell their crop produce, and instead they stored it to deal with anticipated droughts and also farmers reduced their expenses and saved money (Udmale *et al*. 2014). Table 3 clearly depicts that every livestock dependents from each district of non-drought prone, moderately drought prone and severely drought prone adopted and continuing the adoption of the coping mechanism such as 'storage of wheat straw/paddy straw and crop residues (like gram, mustard etc.) at the time when abundantly available'. Majority of livestock dependents of severely drought prone district adopted the practice of 'storage of fodder by making hay and silage' followed by 'preparation of Complete Feed Block (CFB)/ total mixed ration.

Fodder production practices: The studies conducted by Rosenzweig *et al.* (2002) revealed that changes in rainfall patterns and amounts have led to loss of crops/fodder crops and reduced livestock production. In the present study, livestock dependents often used to change their cropping pattern at the time of drought or due to uneven distribution of rainfall. They used to grow drought tolerant crop like sorghum (Jowar), cluster bean (Guar), pearl millet (Bajra), maize (Makka) etc as a fodder crop. The fodder tree as perennial crop like *Subabul* (*Leucaena leucocephala*) was

Table 3. Index score and ranking of strategies for meeting feed shortage in advance as coping mechanism followed by livestock dependents of study area

Stategies for meeting feed shortage in advance	Non-drought prone (Gaya; n=80)	Moderately drought prone (Samastipur; n=80)	Severely drought prone (Bhagalpur; n=80)
Storage of wheat straw/paddy straw and crop residues (like gram, mustard etc.) at the time when abundantly available	1.00 (i)	1.00 (i)	1.00 (i)
Storage by making hay and silage	0.47 (ii)	0.58 (ii)	0.86 (ii)
Preparation of Complete Feed Block (CFB)/Total mixed ration	0.26 (iii)	0.20 (iii)	0.63 (iii)

Values in parenthesis indicates the order of merit of preferences by the livestock dependents column wise

Table 4. Index score and ranking of fodder production practices as coping mechanism followed by livestock dependents of study area

Fodder production practices	Non-drought prone (Gaya; n=80)	Moderately drought prone (Samastipur; n=80)	Severely drought prone (Bhagalpur; n=80)
Change in cropping intensity	0.99 (i)	1.00 (i)	0.99 (ii)
Change in cropping diversification	0.96 (ii)	1.00 (i)	1.00 (i)
Change in irrigation system/pattern (sprinkler/drip/pipe/others)	0.59 (vi)	1.00 (i)	0.77 (vi)
Use water harvesting technology at the time of heavy rainfall to avail livestock and agriculture when there is the scarcity of water during drought	0.09 (ix)	0.29 (vi)	0.54 (viii)
Use of drought resistant/tolerant crop varieties	0.14 (viii)	0.14 (vii)	0.59 (vii)
Altering sowing time/shift planting date of two or more crops	0.74 (iv)	0.98 (ii)	0.86 (iii)
Use short duration or early maturing varieties	0.56 (vii)	0.76 (v)	0.83 (iv)
Growing high yielding perennial and multi-harvesting fodder varieties	0.73 (v)	0.81 (iv)	0.80 (v)
Growing of high yielding fodder/crop varieties	0.81 (iii)	0.95 (iii)	0.80 (v)
Growing of fodder trees	0.02 (xi)	0.04 (ix)	0.30 (x)
Integrated fodder production system (fodder crop between the tree row in orchards or plantation as horticultural and Silvi-pastoral system)	0.03 (x)	0.08 (viii)	0.33 (ix)

Values in parenthesis indicates the order of merit of preferences by the livestock dependents column wise

common tree fodder grown at the time of severe drought in the study area. Livestock dependents purposively used to cultivate early maturing variety of maize for fodder purposes under the stress condition. These local varieties are 'Sathi', 'Jaunpur' etc which used to mature in 70–80 days. Coping mechanisms based on risk minimization such as utilisation of indigenous food sources and growing of drought tolerant crops (Masendeke and Shoko 2013, Mogotsi *et al.* 2011). Local Krishi Vigyan Kendra (Farm Science Centre) used to provide sorghum hybrid variety such as 'Pusa Chari Hybrid 109 (PCH 109)' to the livestock dependents as a contingent plan for fodder purpose in severely drought prone district. Few livestock dependents used to grow lucernes as leguminous fodder crop and they perceived that this fodder crop having higher nutritious value and resulted into higher productivity. They also perceived that this fodder crop could be grown under dry area with a limited resource like irrigation facility. Lucerne is considered as the better leguminous fodder crop in comparison to Berseem (*Trifolium alexandrium*) as Lucerne (*Medicago sativa*) is a perennial fodder crop.

Rural households in general, and farmers in particular, adopted several practices to cope with drought which include irrigation provisioning, shifting cropping pattern and mixed cropping (Kattumuri *et al.* 2015). Table 4 clearly explained that almost all livestock dependents of non-drought prone district and moderately drought prone district were continuing the adoption of coping mechanism as 'change in cropping pattern'. Besides this, change in cropping diversification, change in irrigation system/pattern and alternate in sowing time got the preference during adoption of coping mechanisms. But, growing fodder crops and tree got the least preference among the livestock dependents of drought prone districts of Bihar due to the water scarcity.

Practices followed for sustainable milk production during heat stress: Livestock dependents, who depended on grazing grounds, altered grazing time of their animal during early morning and in evening during hot summer season to protect their animal from heat stress. Maiti *et al.* (2014a) reported that livestock rearers of coastal region took their animal to the grazing ground in the early morning and late afternoon. Generally they did not turn to grazing ground with animal between 11.00 AM to 3.00 PM. Livestock dependents of the study area perceived that feeding and milking during cool hours were very much benefited in terms of productivity and health related problems to animal. They perceived that body required less water after feeding to digestion as like in human during cool hours. Therefore, they used to feed their animal during night hours. They also kept their animal in shadow (either in shade or under the tree) place to prevent from excess water discharge through sweating. Extra bathing of cattle and buffalo was also practiced by the livestock dependents to keep the body temperature down of the animals. To sustain/prevent the heat stress, animal must have higher immunity power; therefore to develop immunity, they used to provide extra concentrate mixture and green fodder.

Table 5 depicts that livestock dependents of drought prone districts of Bihar were very much concerned regarding sustainable milk production of their animal across the different districts of varying degree of drought proneness. Therefore, they continued adoption of the six identified coping mechanisms like grazing of animal during early and cool hours, feeding and milking during cool hours, arrangement of shadow, extra bathing, extra concentrate and extra green fodder. But, the livestock dependents of the non drought prone and moderately drought prone district were having lower preference to the coping mechanism like feeding of animal during night hours.

Modification in management practices: The livestock dependents of severely drought prone, moderately drought prone and non-drought prone district used to made shed outside the household by using locally available paddy straw on roof and side by side along with wet gunny bag which keep the internal temperature down. At the same time, few livestock dependents used fan during hot summer. Hot summer (heat stress) affects the productivity of milk yield if the animals don't provide favourable environment. Knapp and Grummer (1991) reported that either enhance convection by using fans or reduce air temperature by evaporating cooling or to directly cool the cow through

Table 5. Index score and ranking of practices followed for sustainable milk production during heat stress coping mechanism followed by livestock dependents of study area

Practices following for sustainable milk production during heat stress	Non-drought prone (Gaya; n=80)	Moderately drought prone (Samastipur; n=80)	Severely drought prone (Bhagalpur; n=80)
Grazing during early morning and in evening	0.99 (ii)	1.00 (i)	0.97 (iv)
Feeding and milking during cool hours	1.00 (i)	1.00 (i)	1.00 (i)
Kept the animals in shadow place to be maintain thirst at some extent in drought	1.00 (i)	1.00 (i)	0.99 (ii)
Extra bathing of cattle and buffaloes (2–3 times a day)	0.93 (iv)	1.00 (i)	0.99 (ii)
Feeding extra concentrate mixture to overcome heat stress	0.97 (iii)	1.00 (i)	0.98 (iii)
Feeding more green fodder during heat stress	0.93 (iv)	1.00 (i)	0.89 (v)
Feeding during night hours	0.18 (v)	0.16 (ii)	0.73 (vi)

Values in parenthesis indicates the order of merit of preferences by the livestock dependents column wise

using sprinklers and soakers are some of the strategies that may be followed to reduce heat stress. Livestock dependents mainly followed indigenous technical knowledge (ITK) to treat sick animal. The most effective way of combating heat stress in buffalo was wallowing in the water pond.

Livestock dependents, who depended on grazing ground, avoid long distances during heat stress to protect their animals from sun stroke. Few livestock dependents of severely drought prone district shifted their animal to the other bank of Ganga River for two months and used to come back when favourable conditions appear in the area. Majority of the livestock dependents from non-drought prone and severely drought prone districts interested in buffalo rather than cross breed. They responded that buffaloes are more tolerable the stress condition than the cross bred and can be reared by inadequate fodder resources in comparison to cross breed. Cross breed also require higher care and management; ultimately livestock dependents faced loss economically. Majority of the livestock dependents of severely drought prone district reduced their herd size by removing unproductive animals due to scarcity of feed and fodder resources.

Table 6 clearly depicts that livestock dependents modified their management practices to cope up with drought. Coping mechanism like 'used of mosquito net for the family and smoke (fumigation of cow dung or wood) for the animals' was adopted by the almost every livestock dependents and continued this adoption across the districts having varying degree of drought proneness. Coping mechanism practices to drought were long distance grazing, reduced herd size along with tradition prayer for combat to drought (Singh, 2014). Same table also explains that 'reduction in herd size' scored second as a coping mechanism in severely drought prone district.

Other coping mechanism: It was found that majority of livestock dependents used to sell their animal in miserable condition to fulfill the requirement of their family. Along with this if any big issues in the family like fatal diseases, marriages (daughter/sister), they are often selling land to meet the household requirement. Majority of the Livestock dependents of severely drought prone district migrated to the city for the job purpose. It is very difficult to take crop loan for the livestock dependents. Therefore, livestock insurance was very poorly adopted.

Table 6. Index score and ranking of modification in management practices as coping mechanism followed by livestock dependents of study area

Modification in management practices	Non-drought prone (Gaya; n=80)	Moderately drought prone (Samastipur; n=80)	Severely drought prone (Bhagalpur; n=80)
Making of shed outside the household by using locally available resources	0.84 (iv)	0.95 (iv)	0.89 (iv)
Farmer used mosquito net for their family and smoke (fumigation of cow-dung cake) for their animals	0.99 (i)	1.00 (i)	1.00 (i)
Changing of microclimate of the cattle shed by sprinkler/fan	0.59 (ix)	0.93 (v)	0.88 (v)
Use of ITKs to treat the sick animal due to heat stress	0.89 (iii)	0.98 (iii)	0.89 (iv)
To avoid long distance grazing at the time of heat stress	0.91 (ii)	0.99 (ii)	0.91 (iii)
Shifting to small ruminant from large ruminant	0.66 (vii)	0.56 (viii)	0.75 (vi)
Shifting to another place along with animals	0.17 (x)	0.01 (x)	0.53 (ix)
Farmers keep their animals either to their friends or relatives (having availability of fodder resources) during lean period	0.61 (viii)	0.04 (ix)	0.46 (viii)
Keeping/promoting/interested in local breed instead of exotic breed	0.76 (vi)	0.59 (vii)	0.66 (vii)
Reduction in herd size	0.80 (v)	0.83 (vi)	0.98 (ii)

Values in parenthesis indicates the order of merit of preferences by the livestock dependents column wise

Table 7. Index score and ranking of other coping mechanism followed by livestock dependents of study area

Other drought coping mechanism	Non-drought prone (Gaya; n=80)	Moderately drought prone (Samastipur; n=80)	Severely drought prone (Bhagalpur; n=80)
Livestock insurance	0.01 (vi)	0.01 (vi)	0.05 (vi)
Selling of animal for fulfilling household requirement	0.97 (i)	1.00 (i)	0.99 (i)
Selling of land to meet household requirement	0.84 (iii)	0.87 (ii)	0.91 (iii)
Social migration	0.61 (iv)	0.63 (iv)	0.81 (iv)
Search of alternate sources of income	0.89 (ii)	0.74 (iii)	0.97 (ii)
Loan from bank	0.16 (v)	0.29 (v)	0.18 (v)

Values in parenthesis indicates the order of merit of preferences by the livestock dependents column wise

Table 8. Average value and comparative study of adopted coping mechanisms (mean±SE)

Coping mechanism	Non-drought prone (Gaya; n=80)	Moderately drought prone (Samastipur; n=80)	Severely drought prone (Bhagalpur; n=80)
Use of feeding material during drought	72.95±1.60[a]	81.16±0.90[b]	86.52±1.06[c]
Feeding practices followed during drought	63.13±2.32[a]	69.06±1.46[b]	91.72±2.19[c]
Strategies for meeting feed shortage in advance	57.92±2.37[a]	59.17±2.03[a]	83.13±2.45[b]
Fodder production practices	51.31±1.54[a]	64.15±0.77[b]	71.08±2.55[c]
Practices followed for sustainable milk production during heat stress	85.63±0.82[a]	87.95±0.56[a]	93.66±1.08[b]
Modification in management practices	69.55±0.88[a]	69.66±0.65[a]	81.31±0.96[b]
Other coping mechanism	58.02±1.38[a]	59.06±1.16[a]	65.00±1.38[b]
Overall adoption of coping mechanisms	65.59±0.66[a]	70.69±0.43[b]	80.48±1.16[c]

Values at district level with different superscript in a row differ significantly at 5% level of significance, in a two tail test. Multiple comparisons are based on DMRT Post Hoc test.

The adaptation measures adopted by the farmers in semi-arid or drought region included leaving croplands fallow, sale of assets such as livestock and trees, and migration (Kattumuri *et al.* 2015, Udmale *et al*. 2014, Carter and Jansen 2012). Table 7 clearly depicts that selling of animal for fulfilling household requirement was the first preference among most of the livestock dependents of each districts of non-drought prone, moderately drought prone and severely drought prone. Search for an alternate source of income, migrate to the city and selling of land were getting higher preferences among the livestock dependents of drought prone districts of Bihar. But, due to poor level of awareness, they did not prefer livestock insurance. It was also found that acceptability of the institutional credit was very low among the livestock dependents of drought prone districts. 'Loan from bank' and 'livestock insurance' was the fifth and sixth preference for the livestock dependents of all three districts.

Comparative evaluation of the adopted coping mechanisms across the study area: Table 8 clearly explained that all the coping mechanism adopted by the livestock dependents of study area distributed in to 7 categories. It was found that out of seven coping mechanisms, adoption of three coping mechanisms i.e. 'use of feeding material during drought'; 'feeding practices followed during drought' and 'fodder production practices' differed significantly in each district of non-drought prone, moderately drought prone and severely drought prone districts. The mean values of coping mechanism of livestock dependents for 'use of feeding material during drought' was 72.92±1.60, 81.16±0.90 and 86.52±1.06 of non-drought prone, moderately drought prone and severely drought prone, respectively which differ significantly in each district. Similarly the mean values of coping mechanism of livestock dependents for 'feeding practices followed during drought' and 'fodder production practices' were 63.13±2.32, 69.06±1.46 and 91.72±2.19 as well as 51.31±1.54, 64.15±0.77 and 71.08±2.55, respectively of non-drought prone, moderately drought prone and severely drought prone districts, respectively, which also indicates in both these two coping mechanisms differ significantly in each district.

Mean values for the coping mechanism 'strategies for meeting feed shortage in advance' was 57.92±2.37, 59.17±2.03 and 83.13±2.45 for livestock dependents of non-drought prone, moderately drought prone and severely drought prone district, respectively, which indicated that there was no significant difference in adoption among the livestock dependents of non-drought prone and moderately drought prone district. But, the adoption of this coping mechanism by the livestock dependents of these two districts differed significantly with the livestock dependents of severely drought prone district. Same pattern of differences had also been noticed in remaining coping mechanisms such as 'practiced followed for sustainable milk production during heat stress'; 'modification in management practices' and 'other coping mechanisms' in respective districts.

Overall adoption of coping mechanisms of livestock dependents were having mean values of 65.59±0.66, 70.69±0.43 and 80.48±1.16 of non-drought prone, moderately drought prone and severely drought prone districts, respectively. It clearly indicates that overall adoption of coping mechanism increased significantly with increase in degree of drought proneness.

Categorization of the livestock dependents based on their overall adoption of coping mechanisms across the study area: Table 9 clearly depicts that majority of livestock dependents (77.50%) of severely drought prone district fall under higher level of adoption of coping mechanisms, while majority of livestock dependents 82.50% and 60.00% of livestock dependents of moderately drought prone and non-drought prone district fall under medium and lower level of adoption of coping mechanism, respectively.

Step-wise multiple regression analysis of adoption of coping mechanism: As an extensionist, aim must be to improve adoption practices always. Table 10 explains that majority of livestock dependents from severely drought prone district had higher level of adoption. Hence, if we can trace reasons for higher level of adoption and if we can modify or improve these reasons in other districts, then,

Table 9. Percentage of livestock dependents under different categories of adoption of coping mechanisms

District	Low 53.06–67.74	Medium 67.75–78.09	High 78.10–93.88
Non-drought prone (Gaya; n=80)	60.00	37.50	2.50
Moderately drought prone (Samastipur; n=80)	16.25	82.50	1.25
Severely drought prone (Bhagalpur; n=80)	15.00	7.50	77.50

automatically adoption of the coping mechanisms would be improved gradually, with this objective, we traced the reasons of higher level of adoption of livestock dependents in Bhagalpur district by using step wise multiple regression.

Table 10 indicated results of a stepwise multiple regression of dependent variable adoption of coping mechanism on the 8 independent variables of the livestock dependents of severely drought prone district of Bihar i.e. Bhagalpur. In this analysis, F-value for inclusion was 0.05 and for deletion, it was 0.1. Forward stepwise method was followed and it was found that 6 independent variables were included in the model. It may be seen from the Table 10 that the coefficient of multiple determination indicated that the six (6) variables included in the regression equation could predict 70.90% of the dependent variables, adoption of the coping mechanism.

The first variable to enter in the stepwise multiple regression equation of the livestock dependents was number of standard animal unit (X_8). This variable had the highest contribution of 49.70% in predicting the dependent variable i.e. adoption of coping mechanism. The second variable, average total production of buffalo in last lactation per animal (X_5), contributed 10.60% in predicting the dependent variable. The variables frequency of extension contact (X_2) contributed 3.90% in predicting the dependent variable. Fourth variable to enter was family education status (X_4), which contributed 2.50% in the prediction of the dependent variable. Another two variable i.e. average lactation length of the herd (X_6) and average total production of the cross bred per animal in last lactation (X_3) contributed 2.20 and 2.00% respectively.

Deressa *et al.* (2011), Mandleni and Anim (2011), Dhaka *et al*. (2010), Hassan and Nhemachena (2008) and Nhemachena and Hassan (2007) also reported that access to extension service was one of the important determinants of farm level adaptation. But, Maiti *et al*. (2014b) found that 'extension contact' and 'farmer to farmer extension' showed significant positive effect whereas 'numbers of extreme climatic events experienced' and 'proportion income from livestock' showed significant negative effect on adoption of adaptation strategies among the livestock dependents of eastern coastal region of India.

Findings of the study manifest that livestock dependents of drought prone districts of Bihar suffered from drought and adopted several coping mechanisms to mitigate the effect of drought to their livestock production and livelihood security. Feeding of extra crop residues, providing frequent extra clean and fresh feed and water, storage of wheat/rice straw, change in cropping pattern, shifting planting date between two crops, feeding and milking during cool hours, kept animal in shadow, extra bathing of cattle, feeding extra concentrate mixture, selling of animals, reducing herd size, to avoid long distance grazing and search for alternative source of income were the most important coping mechanisms adopted by almost all the livestock dependents during drought. Adoption of coping mechanism to mitigate impact of drought was increased significantly with the increase in degree of drought proneness. Most of the livestock dependents of severely drought prone district (Bhagalpur) were having higher level of adoption of coping mechanism than the moderately drought prone and non-drought prone districts. Number of standard animal unit was considered as the most significant contributor to the higher level of adoption of coping mechanism. Hence the present study will help different government departments like agriculture, animal husbandry and disaster management department to formulate location specific contingency plan at the time of drought to cope up with its impact.

Table 10. Stepwise multiple regression analysis of adoption of coping mechanism among the livestock dependents of the severely drought prone district i.e. Bhagalpur (n=80)

Step no.	Variables entered	Multiple R^2	Increase in R^2	F to enter	Number of independent variables included
1	Number of standard animal unit (X_8)	0.497	0.497	77.22	1
2	Average total production of buffalo in last lactation per animal (X_5)	0.603	0.106	20.469	2
3	Frequency of extension contact (X_2)	0.642	0.039	8.176	3
4	Family education status (X_4)	0.667	0.025	6.359	4
5	Average lactation length of the herd (X_6)	0.689	0.022	4.851	5
6	Average total production of the crossbred per animal in last lactation (X_3)	0.709	0.020	4.555	6

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